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ABSTRACT

This paper reports a study directed toward educational improvement through individual and group change. It is a 3-year naturalistic case study centering on 9 experienced science teachers, 13 novice science teachers, 64 secondary science students, and 4 researchers. The three aims of this study are to know more about: (1) what it is to be a teacher and a learner of science; (2) the changing processes of teachers and students; and (3) research methodology for exploring these aims. First, some background research and the conceptual bases are given. Then an outline of the study design is presented--an outline emphasizing the central role of reflection in determining the approach to, progress through, and outcomes of the research. Some findings from the preservice and inservice components of this study are presented through two types of reflection: reflection on practice and phenomenological reflection. (YP)

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A STUDY OF THE IMPORTANCE OF REFLECTION FOR IMPROVING SCIENCE TEACHING AND LEARNING[1]

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2. J.R. Baird is currently on secondment from the Institute of Education, University of Melbourne.

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INTRODUCTION, NATURE AND PURPOSES OF THE STUDY

This paper reports a study directed to educational improvement through individual and group change. It is interpretive in its approach (Erickson, 1986), and involves teachers, students and academics joining together to research ways of improving the quality of teaching and learning in science classrooms. It is a long-term (3 year) naturalistic case study which centers on 9 experienced science teachers, 13 novice science teachers, 64 year 8-11 secondary science students, and the authors. The three major aims of the study are:

1. Teachers and teaching: learners and learning

   To know more about what it is to be a teacher of science and a learner of science, and the mechanisms which underlie science teaching and learning.

2. Change

   To know more about the processes by which individuals change with experience. Particularly, to explore the effects of a change whereby teachers and students assume greater personal awareness, responsibility and control over their practice.

3. Facilitating change

   To know more about appropriate and productive research methodologies for exploring aim 1 and facilitating aim 2.

First, some background research and the conceptual bases which underpinned the study will be given. Then an outline of the study design will be presented - an outline which emphasises the central role of reflection in determining the approach to, progress through, and outcomes of the research. Next, some findings from the pre-service and in-service components of the study are presented in terms of research involving two major types of reflection - reflection on practice, and

phenomenological reflection. Finally, the results of the study are interpreted in terms of the cognitive, metacognitive, and affective development of the participants.

BACKGROUND TO THE STUDY: UNDERLYING CONCEPTUAL BASES

Research Background

The current project draws together almost a decade of research by the authors. This research originated in three major fields related to science teaching and learning - metacognition, constructivism, and the nature of individual change. The research proceeded in a way in which the interrelationships of these fields became increasingly apparent, and it has culminated intellectually and methodologically in the integrative perspective on change to be discussed in the next section.

Early Studies

In the early to middle 1980's, a series of research studies were directed to fostering students' responsibility and control over their own classroom learning through enhancing their metacognition. As defined here, metacognition refers to a person's knowledge of the nature of learning, effective learning strategies, and aspects of one's own learning strengths and weaknesses, awareness and monitoring of the nature and progress of the current learning task (i.e. what you are doing and why you are doing it), and control over learning through informed, purposeful decision-making (e.g. Brown and Palincsar, 1982). These studies (Baird and White, 1982a, b; Baird, 1986) demonstrated, inter alia, that enhanced student metacognition was desirable for durable learning with understanding, able to be achieved in typical science classrooms, and resulted in improved cognitive and affective outcomes. However, improvement required that both students and their teachers expend considerable time and effort in a process of

significant personal intellectual development. For this development, adequate and appropriate support was found to be necessary in order that participants maintain effort and reach desired goals.

At about the time of these studies, we were also exploring individual's conceptions of science-related concepts (e.g. gravity - Gunstone and White, 1981; stoichiometry - Mitchell and Gunstone, 1984; circular motion - Gunstone, 1984; genetics - Baird, 1984; environment - Fensham and Johnston, 1985), and trying to develop teaching approaches which fostered conceptual change in students who demonstrated various commonly-held conceptual inadequacies (e.g. Gunstone, Champagne, and Klopfer, 1981; Champagne, Gunstone, and Klopfer, 1985). In a later study (Gunstone, 1988a), an attempt was made to explore the extent to which change in students' metacognitive insights and non-cognitive perceptions arose from instruction-driven conceptual change. The success of these, and other, attempts has been mixed (Gunstone, 1988b). Again, the results indicated that time, effort, and support were three necessary conditions for change.

What came from these efforts were some clearer understandings of the role of personal change and, particularly, the importance of constructivism and metacognition in the improvement of science teaching and learning. The term constructivism connotes the essence of the notion. It is that individual learners construct their own understandings of concepts, situations, and so on. This constructed meaning is influenced heavily by the range of existing ideas, beliefs, and attitudes already held by the learner. Constructivism and conceptual change are described more fully in Osborne and Wittrock, 1985, and Posner, Strike, Hewson, and Gertzog, 1982. Particularly significant for us was the realisation of the close complementarity

between constructivism and metacognition in effecting personal change. Adequate metacognition empowers the learner to effectively undertake the constructivist process of recognition, evaluation, and possible reconstruction of personal views and abilities. Indeed, it occurred to us that one reason for the limited success of studies on conceptual change was that the training programs may not have paid sufficient attention to ensuring that learners became sufficiently metacognitive that they could effectively participate in controlling the nature and direction of change (Baird, 1984). What was needed was a study which took account of each of the three notions above and which, in attempting to improve learning through enhanced metacognition, provided conditions which allowed for adequate time, effort, and support for the participants experiencing change. This study, which commenced in 1985, was entitled PEEL.

A synthesis: PEEL

The Project for Enhancing Effective Learning (PEEL) was a naturalistic case study undertaken in a Melbourne secondary school. In this project, teachers and students researched together ways by which students can assume more responsibility and control over their learning. The project was unusual for various reasons, including: the protracted time of the study (originally set at two years but, in fact, still continuing); the extent of involvement of the participants (e.g.: in its first year - 10 teachers, 5 classes, 6 subjects, 3 year levels; in its second year - 14 teachers, 10 classes, 8 subjects, 5 year levels); the intensive nature of the classroom action research (Elliott, 1988) carried out by the teachers and, to a lesser extent, the students; the close, continuing association between the school and various outside 'consultants' (who included most of the current

authors). The project has been very successful. Findings have been obtained which encompass a much wider range of issues than those related directly to teaching and learning: issues related to teacher and student change, innovation, curriculum, school organisation, and professional training and development (e.g. Baird and Mitchell, 1986; Mitchell and Baird, 1986, in press; White and Baird, in press).

Two of the major insights which came from the project will be mentioned here. First, the pattern of improvement in teaching and learning which was achieved demonstrated that the nature and extent of metacognitive development of the teachers was as or more important for success than that of the students. Over the first year of the project, teachers reported substantive changes in their attitudes, perceptions, conceptions and abilities regarding teaching and learning. Particularly, they felt themselves to be more sensitive to students' needs, more aware of the nature and progress of classroom activities, and more informed and purposeful about their teaching behaviours than before the project started (Baird and Mitchell, 1986). The necessity for metacognitive development of teachers for classroom change had not been fully appreciated before the project began. Second, a method of Collaborative Action Research (Baird, Mitchell, and Northfield, 1987) was found to be crucial for teachers' intellectual development. By this method, teachers (or students) and consultants enter into a shared, intensive, long-term process of change and development. The two types of participant (teachers, consultants) bring to the group different perspectives and expertise. Through regular discussion and meetings, group members generate together tentative principles of theory and practice which possess face validity from both perspectives.

Decisions are made regarding action to be taken, the participants attempt to translate principles into practice, and they document and reflect on outcomes. Findings are then brought back to the group for consideration, and the cycle begins again. This style of research sets practice beside theory in order to foster the coordinated development of both. It balances the pressure for change with appropriate support. The support comes from the sharing of the endeavour with others. The importance of collaboration for fostering educational gains is indicated in various research studies into teacher development, school improvement, and educational leadership (e.g., Bolster, 1983; Miller and Lieberman, 1988; Kyle and McCutcheon, 1984).

The findings from PEEL consolidated some of our notions regarding how to go about improving the quality of teaching and learning, amended others, and added more. Above all, the project's findings underlined the necessity for an integrative perspective on, and approach to, change. This integrative perspective, which incorporates the results of the above studies among others, will be described next.

An Integrative Perspective on Change

We believe that the three aims given in the introduction may best be achieved by adopting an integrative perspective on change. The perspective is integrative in that it seeks to:

(i) Combine and synthesise related underlying conceptual bases.

General understandings of the nature of personal change (e.g. Calderhead, 1988; Fullan, 1985; Hall and Hord, 1987) all attribute importance to adequate time, effort, and support in order that change occur. As alluded to above, these conditions may, in part, derive from the constructivist nature of personal change and the necessity for the achievement of adequate metacognition (Gunstone and Baird, 1988),

(ii) Adopt a holistic approach to the study of individuals.

As the individual teacher or learner undoubtedly has a central role in dictating the progress and outcomes of both their own learning, and the learning of those with whom they interact, the individual constitutes a proper focus for research. However, to adequately research such a seemingly unitary focus in fact may require a holistic approach, which takes account of the multiplicity of influences which impinge on this individual. A wide variety of content-related, contextual, and societal factors interact with various personal constructs and attributes. Two terms which draw together such constructs and attributes are intellectual competence and intellectual performance (e.g. Baird, 1988, 1989). Intellectual competence comprises four major cognitive and affective components: Attitudinal traits (including Values and Concerns); Perceptual traits (including Expectations); Conceptions (including Theories and Beliefs); Abilities. Each of these four components interact with the characteristics of the particular teaching/learning episode and with each other to influence the individual's actual intellectual performance. By intellectual performance is meant the person's Attitudinal states (expressed verbally or non-verbally), Perceptions (e.g. awareness of the nature, purpose, and progress of the learning episode), and Decisions and Behaviours about what to do and why, as learning proceeds. The conceptualisations of intellectual competence and performance serve to balance the cognitive and the affective in the study of individuals, and they provide an interpretive structure for the notions of constructivism and metacognition. They provide for a broader view of constructivism than that which applies simply to subject-based conceptions. An individual learns by actively processing information

in terms of all four of the major components of intellectual competence. This processing is manifested as the attitudes, perceptions, decisions and behaviours components of intellectual performance. The notion of metacognition is similarly inclusive, as it subsumes the conceptions and abilities components of intellectual competence, and the perceptions, decisions, and behaviours components of intellectual performance.

(iii) Base the research on personal and professional reflection.

The integrative perspective extends to a balancing of two different styles of reflection, each of which we believe to be important for desirable intellectual development. As will be described in the next section, each type of reflection formed a basis for a different strand of research in the study. The first type is the reflection on practice which Schon (1983) would describe as 'reflection-in-action' - a type which characterises action research (Elliott, 1988). The second type is unlike the first in that it is not tied to the specifics of classroom content and context. It is phenomenological reflection, directed to the underlying 'essences' of an individual's life experiences as a teacher, learner or researcher (e.g. van Manen, 1984).

(iv) converge process and outcomes in teaching and learning.

Where (ii) above relates to the objects of study, this aspect concerns the subjects of the research. Here, the interpretive perspective converges:

- the roles of teacher, learner, and researcher within the 'teachers (or learners) as researchers' notion of action research (Baird, Mitchell and Northfield, 1987; Elliott, 1988),

- research by individuals and by groups, as in the collaborative action research method outlined above,
- the aims of the research, which involve such outcomes as enhanced metacognition and effective conceptual change, with the processes and behaviours by which these aims are practised by the participants through their action research.

This convergence of processes and outcomes within an integrative perspective operates within and among each of the contexts of the research to be described - pre-service teacher training, in-service teacher, school learning. As was mentioned earlier, improving expertise in teaching (whether at pre-service, induction, or experienced levels) is, for the teacher, as much a process of learning as are the classroom tasks and experiences given to the students at school. Thus, in order to understand more of the nature of teaching and learning, it is necessary to consider processes and outcomes in teacher preparation as well as in on-going teacher development.

DESIGN OF THE STUDY

Contexts, Participants, Procedures

The study design has two main components. The first involved science teachers during the pre-service phase of their career. In the project's first year, a group of 13 student teachers and two of their teacher educators engaged throughout their pre-service program in continual guided reflection of both of the two types described above: phenomenological reflection and reflection on practice. The program was one year in duration; all students already held science degrees.

The second component relates to the induction and subsequent in-service phases of teaching. Three members of the student teacher group continued the collaborative reflection begun in their pre-service year

during their first two years of full-time teaching. Additionally, this second component involved a group of 5 practising science teachers at one school, and a group of 4 teachers at another school. These teachers joined with the authors in collaborative phenomenological and action research over the three years of the study.

School students also contributed significantly to the study. For example, in the second year, over 300 year 7-11 students participated in classroom action research on ways of improving their interest, enjoyment and understanding of science. Additionally, 64 year 8-11 students collaborated more intensively by engaging in protracted systematic phenomenological reflection.

Both strands of research - phenomenological and action research - employed a variety of data-gathering procedures appropriate to naturalistic interpretive research. The teachers kept diaries, completed periodic written evaluations, and entered into regular interviews and collaborative research discussions. The students completed written evaluations and questionnaires, and participated in classroom discussions and regular individual and small-group interviews. The authors conferred with teachers as they planned lessons, they observed and audiotaped classroom interactions, and they participated in teacher group meetings to review progress and findings.

Throughout, processes of progressive and post-hoc triangulation (from the perspectives of teachers, students and consultants) were used to validate findings and refine interpretations.

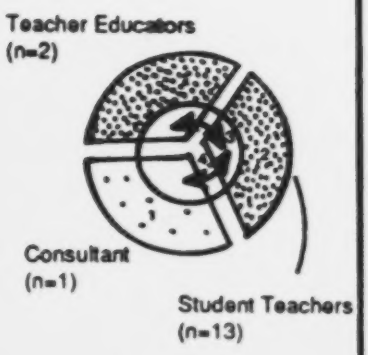
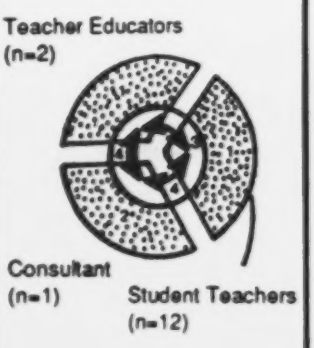
In Figure 1, the overall design of the first two years of the study is presented diagrammatically in order to highlight the central role of reflection in each strand of research. In the figure, the nature of the individual and shared reflection for each of the

participants of the study (pre-service teacher educators, teachers, school students, and consultants/researchers) is indicated. In 1987, the pre and in-service components of the study are outlined. In 1988, novice and experienced teachers joined with their students and the consultants in intensive phenomenological reflection and reflection on practice. In each year, the methods for recording the different reflections are listed.

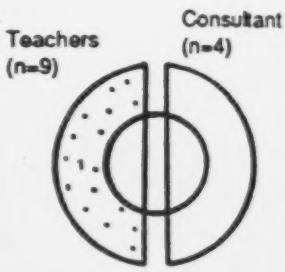
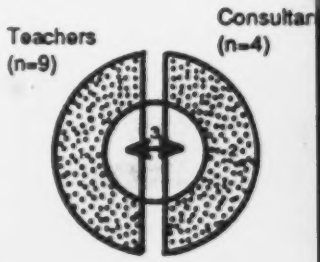
Figure 1. Overall design of the study , as relates to personal and shared reflection, Year 1 and 2[1].

1987

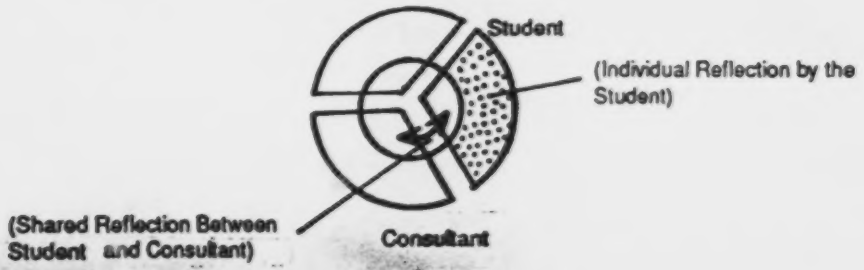
Pre - service

Phenomenological reflection	Reflection on practice
	
1. Diaries 2. Diaries , evaluation sheets 3. Class discussions 4. Interviews, evaluation sheets	1. Diaries, written evaluations 2. Participant observation 3. Class and 1:1 discussions 4. Interviews

In - service

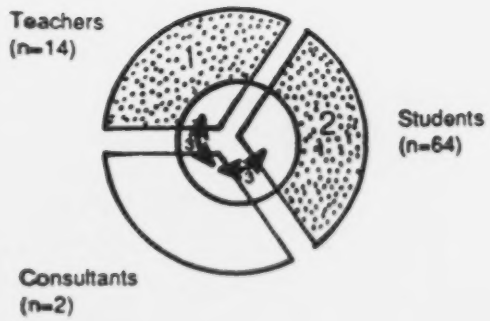
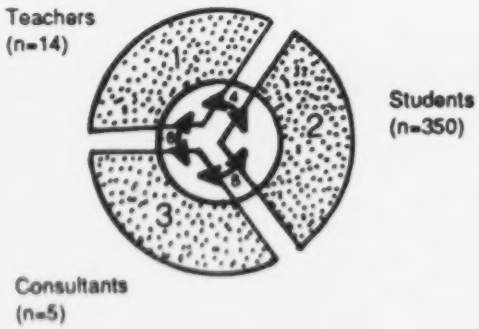
Phenomenological reflection	Reflection on practice
	
1. Diaries (irregularly)	1. Diaries 2. Classroom observations 3. Group meetings

1. The diagrams signify personal and shared reflection as follows:



1988

In - service

Phenomenological reflection	Reflection on practice
	
1. Phenomenological research forms (teacher version) 2. Phenomenological research forms (student version) 3. Interviews / discussions (Individual and group)	1. Diaries and evaluation sheets 2. Evaluation sheets 3. Diaries 4. Class discussions 5. Discussions (individual and group) 6. Group meetings

In the next two sections, some findings from the pre-service and in-service components of the study will be presented in terms of the types of reflection shown in the figure.

RESULTS AND INTERPRETATIONS

Pre-service Teacher Education

The particular Monash University pre-service Diploma in Education (Dip.Ed.) program which is the subject of this research has, for over ten years, run according to a clearly defined constructivist rationale (Gunstone & Northfield, 1986). The most distinguishing feature of the program is that student teachers do most of the year's coursework in stable groups of 15-18 students. Two members of teaching staff are assigned to each group at the beginning of the year, and these staff and students remain together throughout the course. The research to be reported here involved one such group in 1987. This group comprised two teacher educators and 13 intending science teachers. The first author joined the group as participant observer for all aspects of the year's coursework. All members of the group (teacher educators and student teachers) volunteered to contribute to the research. One of the teacher educators is also a member of the group planning and conducting this study.

By its philosophy, design, and manner of implementation, the course already provided opportunities for personal and group reflection. However, the methods employed as part of the research - protracted phenomenological reflection and writing (based on reflecting on such questions as 'For me, what is the experience of doing Dip.Ed. like?' and 'How are my views and beliefs changing?'), clinical interviews, and written evaluations of attitudes, perceptions, behaviours, and performances - extended and deepened these

opportunities. The varied, intensive reflection (undertaken individually, through 1:1 collaboration with another person, or by means of scheduled group activity) is indicated diagrammatically in Figure 1. Most participants used these opportunities for intensive reflection to illuminate and guide their development. It is clear from the figure and from description of the methods that a large quantity of data was generated. A full report of the study (Baird, Fensham, Gunstone, and White, 1989), despite giving detailed information on only four of the students, runs to over 100 typed pages. Some summary data, which are more intensive than will be given here, are reported in Gunstone, Slattery, and Baird (1989).

The most striking findings from the year relate to the personal development experienced by many of the participants. It should be noted that this comment refers as much to the teacher educators and consultant as the student teachers. As would be expected, the nature and extent of this development varied significantly between different individuals. To elaborate these differences adequately would take far longer than is available here. However, two general features which transcend individual differences will be mentioned. The first feature is the importance of reflection for individual teacher development, the second is the importance of collaboration for fostering this reflection.

<u>The importance of reflection for intellectual development</u>.

The observed development involved all components of personal intellectual competence (attitudes, perceptions, conceptions, and abilities), and was of two types:

1. improvement in specific, task-related competencies (e.g. classroom management, utilisation of teaching resources), and

2. development related to more general aspects of intellectual competence (e.g. beliefs regarding the nature of effective teaching and learning; general self-confidence and assuredness; enhanced perceptiveness regarding interpersonal relations).

The first type of development is largely cognitive, and is linked strongly to the specifics of teaching content and context; the second type is of a more general, fundamental nature, and comprises a significant affective component. The desired product of a course of teacher training should show the benefits of both types of development. Yet training for the second type of development is not made explicit in some teacher training courses. As already mentioned, the program provided continuing experiences which stimulated personal development. For the research group, project tasks extended this development by requiring additional introspection and reflection about self, the course, practice, and the future. Indeed, in their evaluations of overall personal change, many of the students emphasised this more general development, and considered it the most valuable outcome of the year. In fact, the emphasis placed by students on this type of development led the researchers to wonder, briefly, whether these students might equally have been served by a type of 'personal growth', 'self-awareness', or 'encounter' program, quite unrelated to specific teacher training. However, both the underlying rationale of this teacher education program and the data obtained in this study point to the need for integrated training for both types of development. Both types of training are necessary, and they seem to be mutually facilitating. For instance, training in specific, purpose-related skills seems to be a suitable basis for effecting general personal development, provided this more general development is also a focus.

This necessity for concurrent training for two types of intellectual development may hold in the wider teaching/learning context. Whatever the subject, learning is more than acquisition of content. It is a process of development in various cognitive and affective components of intellectual competence and performance. Indeed, it is often argued that development in the more general attitudes, conceptions, and competencies is the major objective of education. If so, this development must be explicitly provided for in the design and implementation of instruction.

The findings from this program in 1987 provide two main indications of how this integrated training may be achieved. The first indication is of the fundamental importance of a constructivist perspective for training in both types of intellectual development. Thus, training must take account of, and build on, both the individual's content - or task-based attributes and competencies, and the more general elements of intellectual competence and performance (e.g. those related to personal awareness, sense-of-self, or professional purpose). The second indication is that both types of development are facilitated through personal reflection based on thoughtful, considered introspection. The purpose of this reflection is to enhance metacognition and, thereby, to improve understanding of personal practice.

<u>The importance of collaboration for fostering reflection</u>.

With only one exception, student teachers valued group work as the most, or among the most, important and worthwhile aspects of the course. In fact, most students perceived group work activities and the interpersonal relationships which developed as the fundamental influence on their development. This result is completely in accord

with course objectives. From quite early in the year, the project group developed an ethos and cohesiveness which facilitated individual change, for example:

> *"I saw how important the group was from the very first meeting, how important we were to each other. I realized how important learning from peers is! The discussions we had, the feedback, the encouragement, was very important, not to mention acceptance!"*

The opportunities and support for reflection provided by the group was seen by student teachers as fostering both types of intellectual development mentioned above, but especially the second:

> *"I thoroughly enjoyed being in the [seminar group] sessions, because they were dealing with things that are so absolutely important to anyone anywhere. They were people questions, it doesn't matter whether you are teaching, or what. I wouldn't have missed a [group] session for the world. They provided for growth, they provided a thorough avenue for reflection."*

School Science Teaching and Learning

Earlier, we asserted that progress towards the three project aims required two strands of research, both based on reflection. Whereas the pre-service component of the study centred mainly on phenomenological reflection, in the induction and in-service component we encouraged participants progressively to engage in both strands of reflection concurrently.

As is shown in Figure 1, the nature and extent of the practising teachers' reflection deepened over the first two years of the project and, in the second year, school students became participants in the phenomenological research, and important collaborators in joint research on classroom practice. Some general findings related to both types of reflection will now be discussed.

Some findings regarding reflection on practice as part of on-going classroom action research.

Of the various aspects of the reflection on practice over the

first two years of the project, we have selected for mention only three episodes related to collaboration between teacher and students in reflecting on, and acting to improve the quality of, teaching and learning in science classrooms.

The first episode, entitled a 'Three lesson trialling' of shared reflection on classroom practice, occurred in the project's first year. The detail of this procedure is described more fully in Baird et al (1989), but it basically involved the teacher, each student, and a participant observer (consultant) independently preparing written responses to the four questions shown in Figure 2, near the end of each of a sequence of 3 typical science lessons.

CONFIDENTIAL - DO NOT GIVE YOUR NAME

We would like you to consider <u>today's lesson in science</u>, and answer the following questions.

1. What did you do? (that is what was <u>the topic</u> that you were learning [teaching]?)
2. Why were you doing this topic?
3. How did you go about learning [teaching] this topic? (i.e. what <u>activities</u> did you do in order to learn [teach] it?
4. How well did the lesson go: (Answer 'yes' or 'no', and give reason)
   (a) Was it successful - did you [the students] understand the work?
   (b) Was it clear [to them]?
   (c) Was it an enjoyable lesson [for them]?

<u>Figure 2. Questions asked of students and, in brackets, teachers on the response form, three lesson trialling</u>.

After completion, the consultant collated the students' responses and presented the collated data to the teacher. The teacher and consultant then entered into a detailed exploration of similarities and differences between the teacher's and the students' perceptions of the 'what', 'why', 'how', and 'how well' of the lesson. Subsequently, teachers wrote in their diaries answers to the questions 'Was the trialling a successful learning experience for me?' and 'Is the procedure an acceptable and appropriate research method for teachers?'. This procedure was adopted with 11 of the project teachers with their science classes, which ranged from Year 8 to Year 11.

While the teachers and the consultant derived numerous benefits from the procedure, it proved rather unsettling for the teachers. In the words of one teacher, it proved to be 'another humbling experience'. Many students seemed to have little idea of the answers to such questions as 'Why were you doing the topic?', and their ratings for question 4 (see Figure 2) were often quite negative. Also, there was often considerable disparity between the teacher's, consultant's, and students' responses to question 1, 2, and 3.

However, all the teachers valued the experience. They believed that it had made them reflect more deeply about their practice, and that this enhanced reflection had led to positive change in their classroom attitudes, awareness, and actions. A few representative teacher responses were:

> *'I found talking about the lesson afterwards was valuable. It pointed out to me that the kids should know why they are doing what they are in the lesson, and also that they should enjoy the lesson. It was enlightening to read the summation of students' answers to the questions...It made me think about why I was doing a particular section of work.'*

> *'It made me realise that the students should be more involved in verbalising their thoughts and that, perhaps, I was "dominating the procedure'.*

'During the time that I was working with (the consultant) on the three lessons, I was more conscious than usual of needing to have a very clear idea of exactly what (a) I hoped to achieve during each lesson, and (b) what I expected students to do for each lesson. I believe that I have become more conscious of this in my lessons since'.

In the second year of the study, this procedure was modified by having teachers and students complete a 'Shared Perceptions' form (Figure 3) near the end of selected lessons.

CONFIDENTIAL

DO NOT GIVE YOUR NAME

What I think of science

Question 1 What did you learn about in science over the last week?

About Ferns, Algae, Lichens, and plantlife.

Question 2 Consider your science lessons over the last week.

	A lot	A bit	Not much	Not at all
(a) How much did you look forward to your science lessons?		✓		
(b) How much did you enjoy them?		✓		
(c) How interesting was the work you did?	✓			
(d) How hard did you work?		✓		
(e) How much did you understand of what you were doing and why you were doing it?	✓			
(f) How much do you like your teacher?	✓			
(g) How important is the work you did for you and your future?		✓		
(h) How much did you think carefully about what you were doing?			✓	

Question 3

(a) What was the best thing about science lessons last week?

We could go outside to study plants and didn't have to stay in the classroom all that much.

(b) Why do you think this?

Because sometimes it gets boring just sitting at a desk listening to a teacher tell you about it. This way you can find out for yourself.

Question 4

(a) What was the worst thing about science lessons last week?

Having to draw all the different types of algae etc.

(b) Why do you think this?

Because we were only see what they look like not finding out what parts of the plant were which eg leaves roots etc.

Question 5

(a) Do you think Mr. is teaching science well?

yes

(b) Why do you think this?

Because he lets us work by ourselves and doesn't interrupt while we are working. Also if we ask him a question he will always answer it so we understand it.

Question 6

(a) Do you think you are learning science well?

yes

(b) Why do you think this?

Because I can mostly understand what is being taught.

Figure 3 - One Year 8 student's completed Shared Perceptions Form (Student Version)

This time, the teacher's responses and collated student data were reported back to the teacher and students by the consultant in class and, subsequently, everyone had the opportunity to participate in general discussion about the results and possible interpretations. These discussions, carried out in a supportive, constructive atmosphere, helped identify some of the lesson features and classroom practices which were diminishing students' enjoyment of, and level of application in, science lessons. These features then became the basis for the third episode of this shared reflective process. This episode was entitled the 'Agreement for Change'.

The Agreement for Change started with an extended classroom discussion between teacher and students. In this discussion, all class members identified and agreed to three changes that the teacher would make, and three changes that the students would make, to science classroom behaviours. Selection of particular changes was based on the extent to which teacher and students believed that such changes would enhance students' enjoyment and application. Overall, this procedure was undertaken by 12 teachers and 316 students in 14 classes over Years 8-11 at 5 schools. In Figure 4, the major categories of change agreed to by teachers and students are listed.

Categories of teacher change

1. More clarity of instruction and direction
2. More activeness and variety in work to be done
3. More structure/monitoring of classwork and more control of behaviour
4. More (equal) collaboration between teacher and students

Categories of student change

1. More independence/initiative/activeness
2. More attentiveness/application to the work
3. More responsibility/accountability for work done
4. More cooperative/supportive/courteous attitude

Figure 4: Categories of change agreed to by teachers and students. Agreement for Change procedure

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After entering into this joint agreement, teacher and students attempted to institute the agreed changes. The progress of the agreement was monitored by means of a form which the teacher and each of the students filled in after various periods of time. One student's completed form is shown in Figure 5.

CONFIDENTIAL

Name:
Date: 2.9.93

Year 9 Agreement on Science Teaching and Learning

Weekly evaluation form

A. The agreement

1. Mr _____ has agreed to attempt to make 3 changes to the way he teaches your science lessons. What are these 3 changes?

1. more variety ✓
2. clear instructions ✓
3. simple language. ✓

3/3

2. You have agreed to attempt to make 3 changes to the way you learn in your science lessons. What are these 3 changes?

1. ask more questions ✓
2. get set work done ✓
3. help friends ✓

3/3

B. This week's results

3 (a) Did you notice Mr _____ making any of his 3 changes in this week's science lessons? (Answer 'Yes' or 'No') yes

(b) If you answered 'Yes', - what changes did you notice?

the clear instructions & simple language.

28

(c) How would you rate the effects of his changes in (b) on:

* My enjoyment of the lessons:

I enjoyed the lessons more than normal as a result of his changes ☐

His changes had no effect on my enjoyment of the lessons ☑

I enjoyed the lessons less than normal as a result of his changes ☐

* My understanding of the lessons:

I understood the lessons more than normal has a result of his changes ☑

His changes had no effect on my understanding of the lessons ☐

I understood the lessons less than normal as a result of his changes ☐

---

4. (a) Did you make any of your 3 changes in this week's science lessons? (Answer 'Yes' or 'No') yes

(b) If you answered 'Yes' - what changes did you make?

* support friends

25

(c) How would you rate the effects of these changes on:

* My enjoyment of the lessons:

I enjoyed the lessons more than normal as a result of my changes ☐

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Figure 5 - One Year 9 student's completed Agreement for Change Form

My changes had no effect on my enjoyment of the lessons ☑

I enjoyed the lessons less than normal as a result of my changes ☐

* How hard I worked during the lessons:

I worked harder than normal as a result of my changes. ☐

My changes had no effect on how hard I worked. ☑

I worked less hard than normal as a result of my changes. ☐

* My understanding of the lessons:

I understood the lessons more than normal as a result of my changes. ☑

My changes had no effect on my understanding of the lessons. ☐

I understood the lessons less than normal as a result of my changes. ☐

5. What did you enjoy most about science this week?

discussing the work

6. What did you enjoy least about science this week?

preparing for the test.

Figure 5 - One Year 9 student's completed Agreement for Change Form (cont.)

In Section A of the form, the student (or teacher, for the teacher version) had to remember the changes that had been agreed to by both teacher and students. Then, in Section B, students responded as to whether they believed that the teacher, and they, had acted to fulfil the agreement by attempting to make the agreed changes during the previous week's science lessons. Students then evaluated the extent to which they believed that the teacher's, and their own, changes had affected their enjoyment of the lessons, how hard they had worked, and the extent of their understanding of the work.

While there was some variation in the nature and extent of change among the different working groups, the procedure was very successful overall. Depending on the group, the agreements lasted up to 14 weeks. Detailed collated data are not provided here but, generally:

- students remembered the agreed changes (a median of 92% of all students (range 53-100%, by class) remembered at least 2 of the teacher changes, and a median of 85% of students (range 52-100%) remembered at least 2 of their own changes);
- students believed that teachers were acting to make changes (median 'yes' response to question 3(a) - see Figure 5 - was 86% (range 57-100%);
- of the students who acknowledged teacher change, approximately 55% (: median; range 21-100%) believed that these changes had improved their enjoyment and understanding of lessons;
- students believed themselves to be attempting to enact the changes (median 'yes' response to question 4(a) was 80% (range 47-100%);
- of the students who were acting to change, many of the perceived benefits related to increased enjoyment (median 47%; range 26-92%), working harder (median 54%, range 22-83%) and, very

importantly, understanding more (median 58%, range 27-91%).

It should be noted that while these responses were subjective perceptions by the students, in most cases they were corroborated by their teachers who also recorded improvements in these aspects of classwork.

Why were these agreements so successful? Some main reasons appear to relate to the constructive, cooperative nature of the joint endeavour, the pursuit of concrete goals of importance to the participants, and the clear indications of progress or otherwise. Students and teachers were working as teams, where everyone understood and had agreed to the nature and purposes of the activity. There was clear and balanced accountability for failure to enact the agreement (e.g. students could constructively direct a teacher's attention to a change that the teacher had failed to institute during the period, as could the teacher do the reverse). Conversely, there were concrete and relatively short-term rewards for success at making changes.

These three episodes, culminating in the Agreement for Change procedure, demonstrated the efficacy of individual and joint reflection on practice for improving classroom teaching and learning for the participants. This reflection or practice component of the project is also discussed elsewhere (White, Baird, Mitchell, Fensham, and Gunstone, 1989).

Some findings regarding phenomenological reflection - teachers.

Arising from the pre-service component of the study, which demonstrated the importance of phenomenological reflection for personal intellectual development, it was decided to encourage teachers to undertake regular, protracted, systematic phenomenological reflection. To this end, teachers were asked to complete a confidential form which

contained the same six questions about themselves periodically (ideally, once a month) for a period of up to 9 months. One completed form is shown in Figure 6.

CONFIDENTIAL

Name.....

Date.....

Please answer each of the questions by thinking deeply about YOURSELF

Answer in terms of how you are now. (-not as you think things should be, or how they are for other people).

For me:

1. What is it, to be a science teacher?
   It is to be a person with a poorly defined task. This lack of definition, particularly in regard to the operation of the task, can be extremely frustrating for the new teacher in terms of knowing how to go about achieving goals and in terms of evaluating ones performance. At the same time this lack of definition is a wonderful blessing as it gives me almost total authority over how I teach science. This is not necessarily a good thing for my students or any others for that matter.

2. What is science teaching?
   It is attempting to create an environment(s) which allow, encourage and assist students to better understand their world and (more importantly) gives them skills with which to better answer their own questions (a very crude attempt at saying assist them to become better learners). At the same time science teaching is bringing to students' attention, issues which are likely to be important to them now or in the future

3. What is science learning for my students?
   At present a fairly exciting time (for most) in which they have the responsibility for achieving goals by which ever methods they choose. For others a time in which they have greater opportunity to do less (due to the nature of the teaching approach). For all - a poorly defined task during which they are frequently uncertain of what is expected of them.

4. What is the most important pay-off in science teaching?
   Helping students to be better learners and part of this being their expressions of seeing this as a positive thing.

5. What is the most important cost, or worst aspect, of science teaching?
   Uncertainty of how one is performing, i.e. lack of professional feedback and the consequent difficulty to motivate oneself.

6. What has answering the five questions above made me do/think about?
   Reflect on the objectives of my professional task, in particular the importance of helping students to become better learners. It is a helpful tool in my development. It also serves as a reminder of the underlying objectives of my task - something which, despite its fundamental importance seems to be lost in the crowd of more pressing day to day concerns of teaching.

Figure 6. A teacher's completed phenomenology form

For various reasons not discussed here, teachers varied in the number of forms they completed, and in the insightfulness of their answers. Of the 14 teachers, 11 filled in more than one form, and 4 filled in more than five. Informal discussions were held periodically with teachers to discuss their perceptions of the questions and the nature of their answers.

Most teachers appeared to gain benefit from repeatedly reflecting on the questions, some very much so. These benefits are indicated by their answers to question 6: 'What has answering the five questions above made me do/think about?'. Some of the many positive responses to this question were:

> *'Whether I practice what I preach. Am I really aware of my students' perceptions of science learning?'*
>
> *'Consider the reasons why I teach and what students probably feel about the subject'*
>
> *'It has made me focus on the important aspects of motivation and interest'.*
>
> *'How my enthusiasm and approach obviously affects the students' behaviour - I must act enthusiastic regardless of the way I feel!'*
>
> *'The underlying goals of my work. Strengthened my resolve that my style of teaching is more likely to achieve my goals than previous styles'.*

Some findings regarding phenomenological reflection - students

Sixty-four Year 8-11 students at two schools volunteered to participate in a process of phenomenological reflection similar to that described above for the teachers. A form similar to that of the teachers' was completed periodically by these students over a period of six months. One completed form is shown in Figure 7.

CONFIDENTIAL

Name: .....

Date: .....

Please answer each of the questions by thinking deeply about YOURSELF. Answer in terms of how you are now (NOT as how you think things should be, or how they are for other people).

---

1. What is it, to be a science student? (Base your answer on how you feel)
   For me, it is: *just another subject at school that I have to go through. Although I may learn different things in science than in any other subject it is still just a compulsory subject at school that everyone has to do.*

2. What is science learning? (Base your answer on what you do)
   For me, it is: *answering questions, doing assignments, having class discussions, doing some prac experiments and finding out about things that don't really interest me at all.*

3. What is the most important pay-off in learning science? (Base your answer on what you get out of it most)
   For me, it is: *when we do things about nature, for example: plants, animals, the earth. I think the more people know about the natural part of life, the better.*

4. What is the worst aspect of learning science? (Base your answer on what you dislike most)
   For me, it is: *having to sit through science when we are doing a totally boring topic, e.g. machines, electricity.*

Figure 7. A Year 9 student's completed phenomenology form

Over the 6-month period, most students completed approximately 3 forms. In addition to filling in the forms, each of these students were interviewed 3-7 times, individually and in groups, about their general ideas and beliefs, and their particular responses to the questions on the form.

Again, detailed information regarding this process of reflection cannot be given here, but many students considered it to be beneficial. At the end of the procedure, 21 students at one school were interviewed individually about their perceptions of the effect of the procedure on them. Of these 21 students, 12 clearly asserted that completing the forms and having the discussions had helped them. Five other students were also positive, but somewhat less definite. Fourteen of the students believed strongly that it was important for them to be reflective in their classwork, and 10 of these believed that they had been moved to this view by doing the project activities.

CONCLUSIONS

Taken overall, findings from the study illuminate each of the three aims given in the introduction. These findings include:

Aim 1 (Teachers and teaching; learners and learning).

The phenomenological reflection has provided insights into the personal 'lived experience' of teaching and learning which are unobtainable by other methods. These insights highlight the singularity and complexity of factors which influence the teaching/learning approach, progress and outcomes.

The findings from the phenomenological research assisted interpretation of the extensive results arising from the collaborative action research. In the latter research, teachers and students worked together to explore aspects of science teaching and learning, and to devise ways of changing classroom roles and responsibilities to preserve and develop desirable cognitive, metacognitive and affective outcomes. The research has generated significant gains in the levels of satisfaction and performance of both teachers and students.

Aim 2 (change).

The changes referred to above have led to students accepting a greater level of accountability and responsibility for their own learning. The improved intellectual competence and classroom intellectual performance of students, associated with enhanced metacognition, has been more than matched by enhancement in teachers' self-perceived and actual metacognition. Teachers have changed to become more perceptive, resourceful, and purposeful classroom practitioners. The manner of development of teachers' expertise in teaching and ability to research teaching and

learning in their classrooms is in accord with constructivist principles of attitudinal and conceptual change.

Aim 3 (Facilitating change).

For teachers and students, change was in both general intellectual development and in more specific task competencies. For both types of improvement, the opportunity for intensive, regular reflection was crucial. The nature and extent of change was found to be dependent on the exercise of certain responsibilities by different members of the collaborative group. One measure of the extent of change was the transfer of many of these responsibilities from the authors to the teachers and students themselves.

In particular, findings from the study strongly reaffirm the importance of two key aspects of the integrative perspective on change described earlier. These results relate to the need for personal and professional reflection, and the facilitation of reflection through collaboration. It appears that both of the two types of reflection discussed earlier are necessary and mutually facilitating for enhancing professional expertise through enhanced metacognition. One interpretation of this finding relates to science teachers' conceptions of cause in science, and in science teaching and learning. Conceptions of cause which pervade science and much school teaching and learning of science are often monistic (unitary) and absolutist (invariant). That is, there is striving to discover the one correct explanation of a particular scientific phenomenon, the one most elegant procedure for testing an hypothesis, and so on. The veracity and applicability of such explanations or procedures are taken to transcend time, context

and, for some 'universal laws', content. Unlike science itself, however, cause in teaching and learning is unlikely to be unitary and invariant. It is much more likely to be multiple (pluralistic) and content-, context- and time-dependent (relativistic). For example, most teachers would acknowledge that the success of a particular lesson is influenced by the nature of the content and the particular students in the class, and the method of presentation, and the time of day, and the ambient temperature, and so on. Conception of cause is particularly relevant to the nature of successful teaching - one of the objects of the current research. In order that science teachers become successful, they may need to apply this pluralistic, relativistic conception of cause to their own development. Conceptions of the nature of successful teaching as law-governed and generalisable need to change to ones which take it to develop in a constructivist manner through a process of individual reflection on personal life experiences (i.e. phenomenological reflection). Results from the phenomenological strand of the current research indicated such development. Collaboration fosters reflection by providing a means of exchange of information and resources, and provision of support during the demanding and unsettling change process.

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